Question			Expected Answers	M	Additional Guidance
1					
	a		same frequency / period different amplitude / phase	B1 B1	**accept** wavelength / sinusoidal /AW **accept** + sine and – sine for 2 marks
	b		because the waves have a <u>constant</u> phase relationship **or** are <u>continuous</u> and have the <u>same</u> f/period/λ they are coherent	M1 A1	**accept** same phase relationship for 1 mark only
	c		use of 3 ms as period $f = 1/3.0 \times 10^{-3} = 330$ (Hz) using $v = f\lambda$ $340 = 330\ \lambda$ $\lambda = 1.0(2)$ (m)	C1 A1 C1 A1	 **ecf** for f possible e.g. λ = 1020 (m) **accept** 1.03 (m) **no** SF error here
	d	**i**	0	B1	
		ii	1.0 (μm)	B1	**look for** SF error i.e. zero for 1 (μm)
	e	**i**	Intensity α (amplitude)^2 so ratio is $(3/2)^2 = 9/4$ (giving 2.25 I)	C1 A1	**allow** $I \alpha A^2$
		ii	resultant $A = A_S + A_T = (\pm)\ 1$ so ratio is $(1/2)^2$ giving 0.25 I	C1 A1	**ecf** from **(d)(ii)**
	f	**i**	phase shift of π or 180^o required **or** movement of λ/2 1.02/2 = 0.51 (m)	B1 B1	**ecf** from **(c); accept** (2n + 1)/2 λ **accept** 0.50 m
		ii	intensity increases to the maximum value	B1 B1	**accept** quantitative answers, i.e. from 0.25 I to 6.25 I
			Total question 4	**18**	

Question			Expected Answers	Marks	Additional Guidance
2					
	a	**i**	λ distance between (neighbouring) identical points/points with same phase (on the wave) f number of waves passing a point /cycles/vibrations (at a point) per unit time/second v distance travelled by the wave (energy) per unit time/second	B1 B1 B1	**accept** peak/crest to peak/crest, etc. **accept** number of waves produced by the wave source per unit time/second **not** v = f λ and not 'in one second'
		ii	in 1 second f waves are produced each of one wavelength λ distance travelled by first wave in one second is f λ = v	M1 A1	**accept** time for one λ to pass is 1/f so v = λ/(1/f) =f λ **give** max 1 mark for plausible derivations purely in terms of algebra (no words)
	b	**i**	infra red is part of the e-m spectrum lower f **or** longer λ than the visible region/light **or** suitable value or range of λ	B1 B1	 **accept** any single λ in range 10^{-5} m to 7.5 x 10^{-7} m or any reasonable wider range
		ii1	λ = c/f = 3.0 x 10^{8}/ 6.7 x 10^{13} 4.5 x 10^{-6} (m)	C1 A1	 **accept** 4.48 x 10^{-6} or more s.f.
		2	T = 1/f = 1/6.7 x 10^{13} T = 1.5 x 10^{-14} (s)	C1 A1	 **accept** 1.49 x 10^{-14}
		iii	at least one cycle of a sine or cosine curve as judged by eye amplitude 8.0 x 10^{-12} m period = 1.5 x 10^{-14} s	B1 B1 B1	**ecf (b)(ii)2**
			Total question 5	**14**	

Question			Expected Answers	Marks	Additional Guidance
3					
	a	**i**	when (two) waves meet/combine/interact/superpose, etc. (at a point) there is a change in overall intensity/displacement	M1 A1	**allow** for A1 mark: (vector) sum/resultant displacement(s)/AW
		ii	constant phase difference/relationship (between the waves)	B1	just stating same frequency **not** sufficient
	b	**i**	path difference of nλ for constructive interference producing **either** maximum amplitude/intensity **or** a maximum path difference of (2n + 1)λ/2 for destructive interference producing **either** minimum amplitude/intensity **or** a minimum	M1 A1 M1 A1	**allow** waves arrive in phase **allow** waves arrive in anti-/out of phase **max** 3 marks; max 1 mark for two correct marking points but with n omitted
		ii	x = λD/a = 0.030 x 5.0/0.20 =0.75 (m)	C1 A1	**give** 1 mark max for 0.75 mm but zero for 750 m
		iii 1	intensity increases by factor of 4 position unchanged	B1 B1	
		2	intensity unchanged distance apart of maxima is doubled	B1 B1	
		3	intensity unchanged maxima move to positions of minima (and vice versa)	B1 B1	
			Total question 6	**14**	